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Structural Equation Modelling for Analysing Passengers' Perceptions about Railway Services

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Abstract

In this work a tool for analysing passengers' perceptions in terms of satisfaction with transit services is proposed. Specifically, a structural equation model is formulated to explore the impact of the relationship between global customer satisfaction and service quality attributes, such as safety, cleanliness, main and additional services, information, and personnel. We analyse the services offered by rail operators in the Northern Italy; specifically, 32 regional lines and 9 suburban lines connecting different towns of the hinterland of the city of Milan, and 2 express lines connecting Milan with the Malpensa airport are analysed. To calibrate the model, data collected in a survey addressed to a sample of more than 16,000 passengers are used. The survey was conducted in June 2011.

The proposed model can be useful both to transport agencies and planners to analyze the correlation between service quality attributes and identify the most convenient attributes for improving the supplied service. The main findings are that service characteristics like punctuality, regularity and frequency of runs, and cleanliness have the highest positive effect on service quality. While also comfort and information have a notable positive effect, personnel and safety have a not very considerable effect.

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1. Introduction

Public transportation systems provide the most efficient means for moving large number of people, especially in density populated urban centers. For this reason, providing services characterized by high levels of quality is very important in order to customize the users of the services and attract new users.

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Quality evaluation of public transit services is still a key issue in transport engineering, as transit is often argued as a promising travel mode to reduce automobile dependence, thereby alleviating environmental pollution, reducing energy consumption, lessening traffic congestion, and enhancing quality of life and mobility (Nocera, 2011).

A transit service is characterized by a series of service factors concerning different aspects such as service programming, reliability, comfort, information, personnel, and so on. Therefore, transit quality depends on the quality levels of all the factors describing a transit service. Customer satisfaction is one of the key determinants to measure the quality of a service. The proposed research is just oriented to the measurement of transit service quality based on the perceptions of the passengers.

More specifically, the proposed work aims to an investigation of the influence of a series of service quality attributes on the overall service quality of a railway service. We adopt users' perceptions expressed in terms of satisfaction and importance for verifying this influence and the presence of latent variables better explaining these kinds of relationship. We propose at this aim a model based on the Structural Equation Modeling (SEM) methodology.

The paper is structured in five sections. We propose a brief literature review of some works concerning the analysis of customer satisfaction in public transport proposing the use of the SEM for investigating about it; the aim of the review is just to demonstrate that this kind of methodology can be useful for analyzing customer perceptions about the services. Then, there is a section describing the study case adopted as a support of the research: the survey conducted for collecting data is briefly described, the main characteristics of the sample are shown, and the analysis of the importance and satisfaction rates is described. The fourth section contains the description of the proposed model: after a brief theoretical framework about the methodology, we describe the structure and the results of the introduced model. Finally we propose a brief conclusive discussion of the work.

2. Literature review

The analysis of data regarding customer satisfaction and transit service quality can be made by methods based on factor analysis, which have been adopted in several fields of research, such as Principal Component Analysis (PCA), Confirmatory Factor Analysis (CFA), and SEM, which represents a more advanced methodology. Concerning transportation system, some examples of applications based on PCA are reported in the literature. Rahaman and Rahaman (2009) focused on the railway transportation sector to develop a model defining the relationship between overall satisfaction and twenty service-quality attributes. Kolanovic et al. (2008) presented the methods of choosing the possible attributes affecting the perception of the port service quality. Ching-Chiao et al. (2009) have used PCA to identify crucial resources and logistics service capabilities in container shipping services. Lai (2010) explores the relationships between passenger behavioral intentions and the various factors that affect them in a new public transit company in Taiwan. Chin-Shan (2007) has investigated the key factors affecting the adoption of internet services in the context of liner shipping services. Pantouvakis (2010) conducted a study in Greece to assess the relative importance of various service-quality dimensions in explaining customer satisfaction. the study of Sezhian et al. (2011) aims at evaluating the customer expectations of public transport service sector in India.

In the transport sector literature there are also some applications concerning CFA. Yu and Lee (2011) measured the relative influence of perceived service quality of low cost carrier airlines in South Korea on customer satisfaction. Chenga et al (2008) developed a model to investigate the important issues of airline relationship quality from the customer's perspective in Taiwan. Changa and Chen (2007) studied customer loyalty for Taiwanese air travellers.

SEM was adopted in several fields of research and generalized by Joreskog and Wiley (Joreskog 1973; Wiley 1973). SEM was applied in Psychology and Social Science, Natural Science, and especially in the field of Economy and Statistics. In the field of transportation research some applications of SEM were proposed to

analyze land-use and transport interactions (e.g. Tschopp and Axhausen, 2007; Van Acker et al., 2007; Abreu e Silva and Goulias, 2009). Also in public transport some authors proposed SEM applications, such as Bamberg and Schmidt (1998), Fillone et al. (2005), Tam et al. (2005). More specifically, SEM was also adopted for investigating on customer satisfaction on public transport services, but there are not many studies in this field. Examples are Andreassen (1995), Stuart et al. (2000), Karlaftis et al. (2001), Eboli and Mazzulla (2007), Ngatia et al. (2010), and Irfan et al. (2011).

Andreassen (1995) investigated on the differences between public and private services, and particularly whether customer preferences for public services are homogeneous while preferences for private services are heterogeneous. The analysis was based on an empirical study of 1,000 customers using either bus, train or tram in and around the greater area of the capital of Norway. The main finding is that individual customer preferences exist and that high and low-frequency users of public transportation services have different preferences. Implementing differentiated public services will improve the satisfaction score, i.e. expected utility, and thereby reduce the need for privatizing the industry.

In Stuart et al. (2000) a transit service in New York was analyzed. Users expressed a judgment in terms of rates according to a numerical scale from 1 to 10 about some service aspects and the overall service. Through a structural equation model the strength of the relationships among the service aspects can be quantified and compared with one another in terms of both direct and indirect effects.

Karlaftis et al. (2001) used data from the Athens, Greece, bus and trolley bus systems for demonstrating the potential use of structural equation modeling for measuring customer satisfaction. The questionnaire results yield essential information in determining current and near-term requirements and customer expectations, helping set priorities for service improvements, identifying system weaknesses, targeting user groups and identifying their specific needs, and setting performance benchmarks that can be used to compare the system to its competitors and track its performance over time.

Eboli and Mazzulla (2007) proposed a model for investigating the impact of bus transit aspects on global customer satisfaction. An urban bus service of an area of the Southern Italy habitually used by university students was analyzed. The latent variable model relates the three exogenous latent variables (Network design, Service planning and reliability, Comfort and other factors) to an endogenous latent variable, named "Satisfaction". The latent variable with a major effect on global customer satisfaction is "Service planning and reliability".

Also in Ngatia et al. (2010) public transport service attributes influencing overall passengers' satisfaction were investigated. A survey to public transport users was conducted in the city of Nairobi. The proposed structural equation model allowed elucidating the interrelationship between the observed variables and unobserved variables and their impact to the overall commuters' satisfaction. Unobserved attributes such as Service Quality, Safety and Travel Cost were estimated. Level of satisfaction was found to be significantly influenced by these attributes.

Irfan et al. (2011) aimed to investigate the passengers' perceptions about the service quality of rail transport system in Pakistan while traveling between the major cities. Several latent variables were introduced in the proposed structural equation model: tangible, empathy, assurance, responsiveness, timeliness, food, information, safety. Only tangibles have a positive and significant impact on passenger satisfaction.

All the above described research works demonstrates that SEM is a very useful tool for investigating on customer satisfaction and transit service quality, because it allows some latent aspects to be revealed.

3. Study case

3.1. Survey

The survey was addressed to a sample of users of a railway service operating in the North of Italy. The service offers different types of connections: 32 regional lines and 9 suburban lines connecting different towns of the

hinterland of the city of Milan, and 2 express lines connecting Milan with the Malpensa airport.

Face-to-face interviews were realized in the period from the end of June to the middle of July 2011, during the whole week and then considering weekday, before a holiday, and holiday days, in a time slot between 6.00 a.m. and 10.00 p.m. Passengers were prevalently interviewed on board during their journey. A final simple random selected sample of 16,718 people aged more than 16 was considered for analyzing the investigated services, guaranteeing a sample rate of 3% (calculated on the basis of the registered number of passengers per day of 572,040).

The questionnaire was structured into two main sections. The first section had the aim of collecting data concerning: general information (e.g. time period of the interview, train, line, station, operator); socio-economic characteristics (e.g. gender, age, qualification, professional condition, car availability, income); travel habits (e.g. trip scope and frequency, ticket, transport modes connecting with the train stations). The second section was more oriented to the passenger perceptions about the used services. Specifically, users expressed importance and satisfaction rates, on a cardinal scale from 1 to 10, about 33 service quality factors concerning safety, cleanliness, main and additional services, information, and personnel. Users also provided deeper information about some railway services such as convenience of this kind of services compared to the others, or ticket purchasing, or information services.

About 53% of the interviewed people are passengers of the regional lines, about 40% of the suburban lines, and the remaining 7% travel through the Malpensa express services. 80.5% of users were interviewed in a weekday, 14.2% in a before a holiday day, and 5.3% in a holiday. Most of the passengers were interviewed in the off-peak hours (56.0%), 18.7% in the afternoon peak-hours, 13.8% in the evening peak hours, and 11.5% in the morning peak-hours. 30.6% of sample are commuter workers, 13.6% are students, and the remaining 55.8% belongs to other categories of people.

3.2. Sample characteristics

Sample is almost equally spread between females and males (table 1). The major part of interviewed passengers are aged between 16 and 25, and another fair chunk is represented by people aged between 26 and 40. Most of the sampled people are employees, and a considerable part is composed of students; about 8% of passengers are freelancers, and the remaining 20% is spread among other professional conditions such as pensioner, manager, self-employed worker, unemployed and housewife. About 35% doesn't give any kind of information about the income; most of people stating their income belongs to a class of income lower than 1,000 Euros (25% of the whole sample) and a class between 1,001 and 1,500 Euros (19.3%); 12.0% belongs to a class 1,501 and 2,000 Euros, and the remaining 9% belongs to classes characterized by income levels more than 2,001 Euros. More than half of the sample obtained a diploma of a secondary school of second level, more than one third has a degree, about 12% obtained a diploma of a secondary school of first level, and only 1.3% of a primary school. Finally, 58.1% of sampled people owns a private car.

Most of the passengers travel by train for reaching the place of work, almost one third travel for making personal activities, and more than 20% for reaching the study places. Almost half of the sample travels by train every day, but about 35% of passengers occasionally travel. Most of the sample purchases a monthly card or a one-way ticket; about 16% adopts a return ticket, while about 21% travels by using other kinds of card or ticket (e.g. weekly or yearly card, or multi-run ticket). Also information about the transport modes used by passengers for arriving to/moving from the stations were collected. Particularly, most of the sample arrives to/moves from the stations on foot or by other transit systems; 14.0% of passengers reach the stations by their own car and about 9% by travelling as a passengers of a car; analogously, about 11% of passengers move from the station by their own car and about 8% by travelling as a passengers of a car; the remaining part of passengers reach or move from the stations by other transport modes such as bicycle, motorcycle, taxi, train.

Table 1. Sample characteristics

Characteristics	Statistics
1. Gender	Male (45.5%), female (54.5%)
2. Age	16-25 (36.7%), 26-40 (33.8%), 41-65 (25.6%), > 65 year-olds (3.9%)
3. Professional condition	employee (40.5%), manager (4.2%), entrepreneur (2.1%), freelancer (8.2%), self-employed worker (3.7%), unemployed (3.4%), student (30.5%), housewife (2.4%), pensioner (4.5%), other (0.6%)
4. Income level	<= 1,000 (25.0%), 1,001-1,500 (19.3%), 1,501-2,000 (12.0%), 2,001-3,000 (4.9%), 3,001-4,000 (1.6%), > 3,000 Euros (2.2%)
5. Qualification	Degree (32.9%), diploma of secondary school of second level (53.4%), diploma of secondary school of second level (12.4%), diploma of primary school (1.3%)
7. Car ownership	Have car (58.1%), have not car (41.9%)
8. Scope of journey	Work (42.3%), studying (21.3%), bureaucratic activities (3.3%), personal activities (26.7%), tourism (6.4%)
9. Frequency of journey	Daily (46.8%), weekly (18.0%), occasionally (35.2%)
10. Ticket kind	One-way ticket (29.4%), return ticket (16.4%), multi-runs ticket (3.1%), weekly travel card (8.0%), monthly travel card (32.7%), yearly travel card (6.0%), "I travel" special card (4.4%)
11. Access transport mode	On foot (37.3%), by car as a driver (14.0%), by car as a passenger (8.7%), by bicycle (2.1%), by motorcycle (5.1%), by other transit systems (25.5%), by taxi (1.0%), by train (0.7%), by more than one modes (0.5%), n.d. (5.0%)
12. Egress Transport mode	On foot (38.6%), by car as a driver (11.2%), by car as a passenger (8.2%), by bicycle (1.5%), by motorcycle (3.9%), by other transit systems (27.5%), by taxi (0.9%), by train (0.5%), by more than one modes (0.2%), n.d. (7.5%)

3.3. Importance and satisfaction rates

Importance and satisfaction rates were expressed by the interviewed users, on a scale from 1 to 10, on 33 service quality attributes. Table 2 shows the average rates calculated from the collected data.

Users retain all the attributes as very important (having an average rate of importance around 8 and 9) with the exception of the attribute linked to the possibility to transport the bicycle on board, for which an average importance rate of 7.3 was obtained. On the contrary, by observing the average satisfaction rates we can say that people judge as not very good most of the service characteristics, in fact only nine attributes have an average rate higher than the sufficiency (>6). More specifically, the attributes considered as the most important are the three service aspects linked to travel safety and personal security, which have an average importance rate higher than 9. Among the attributes considered as less relatively important there are the services linked to the possibility of parking at stations, the maintenance of the stations, the activities of communication to the offices, the activities of ticket inspection, which however show an importance rate higher than 8. Concerning satisfaction rates, we can see that the service characteristics considered as the most satisfying are linked to all the characteristics regarding safety, to all the aspects concerning the personnel, and to the integration with the other modes of public transport and the localization of the stations. On the contrary, the characteristics judged as the less satisfying are linked to aspects concerning cleanliness, comfort, and information. Specifically, two attributes registered a satisfaction rate lower than 5: cleanliness of seats and cleanliness of toilet facilities.

By observing the variance of the importance and satisfaction rates (table 2), we can easily observe that users' perceptions in terms of satisfaction are more heterogeneous than importance judgments. In fact, the average variance calculated by considering the variance of all the satisfaction rates is about 5.1, while the corresponding average variance relating to the importance rates is about 3.3. The attribute judged in the most heterogeneous way in terms of satisfaction is the aspect relating air-conditioning on board, while the less heterogeneous is the aspect linked to the competence of the personnel on board. Concerning importance rates, the attribute judged as the most heterogeneous is the aspect relating the possibility to transport the bicycle on board, while the less heterogeneous is also in this case the aspect linked to the competence of the personnel on board.

Table 2. Importance and Satisfaction rates

<i>Service quality attribute</i>	Importance rate	Satisfaction rate	Importance var	Satisfaction var
F1 Travel Safety	9.2	7.4	2.6	4.6
F2 Personal Security on Board	9.1	6.7	2.6	4.9
F3 Personal Security at Station	9.1	6.5	2.8	5.1
F4 Cleanliness of Vehicles	8.9	5.0	3.4	5.5
F5 Cleanliness of Seats	8.9	4.8	3.5	5.6
F6 Maintenance of Seats	8.6	5.1	3.5	5.6
F7 Cleanliness of Toilet Facilities	8.8	4.4	3.8	5.7
F8 Cleanliness of Stations	8.5	5.3	3.3	4.9
F9 Maintenance of Stations	8.3	5.4	3.7	4.9
F10 Crowding on Board	8.4	5.4	3.5	5.7
F11 Air-conditioning on Board	8.7	5.1	3.1	6.0
F12 Comfort on Board	8.4	5.6	3.1	5.2
F13 Fare/Service Ratio	8.8	5.1	3.4	5.5
F14 Frequency of Runs	8.9	5.9	2.6	5.1
F15 Punctuality of Runs	9.0	5.4	2.9	5.8
F16 Regularity of Runs	9.0	5.7	2.6	5.2
F17 Integration with PT	8.7	6.0	3.0	4.9
F18 Localization of Stations	8.6	6.5	2.7	4.4
F19 Parking	8.0	5.7	4.9	5.5
F20 Bicycle Transport on Board	7.3	5.8	5.8	4.6
F21 Facilities for Disabled	8.8	5.2	3.8	5.7
F22 Substitute Services	8.4	5.4	4.0	4.9
F23 Information at Stations	8.7	5.9	2.9	4.7
F24 Information on Board	8.5	5.5	3.3	5.0
F25 Info Timeliness at Stations	8.7	5.5	3.0	5.0
F26 Info Timeliness on Board	8.6	5.3	3.2	5.2
F27 Complaints	8.5	5.0	3.7	5.5
F28 Communication to Office	8.3	5.1	3.7	5.3
F29 Info Connections with PT	8.5	5.4	3.3	5.0
F30 Kindness on Board	8.5	6.6	2.7	4.2
F31 Competence on Board	8.7	6.6	2.5	4.1
F32 Ticket Inspection	8.3	6.3	3.8	5.2
F33 Kindness of Station	8.6	6.4	2.9	4.9
Overall service		5.8		4.6

4. Model

4.1. Structural Equation Modeling methodology

SEM methodology spread fast as a consequence of the development of specific packages, like LISREL (Joreskog and Sorbom, 1988; Joreskog and Sorbom, 1989; Joreskog and Sorbom, 1995) and AMOS (Arbuckle and Wothke, 1995); the availability of these packages has encouraged several applications in different contexts. This approach allows the modelling of a phenomenon by considering both the unobserved “latent” constructs and the observed indicators that describe the phenomenon. Structural equation models are made up of two components: the first one describes the relationship between endogenous and latent exogenous variables, and permits the evaluation of both direction and strength of the causal effects among these variables (latent variable model); the second component describes the relationship between latent and observed variables (measurement model).

The basic equation of the latent variable model is the following (Bollen, 1989):

$$\eta = B\eta + \Gamma\xi + \zeta \quad (1)$$

in which η (eta) is an $(m \times 1)$ vector of the latent endogenous variables, ξ (xi) is an $(n \times 1)$ vector of the

latent exogenous variables, and ζ (zeta) is an $(m \times 1)$ vector of random variables. The elements of the B (beta) and Γ (gamma) matrices are the structural coefficients of the model; the B matrix is an $(m \times m)$ coefficient matrix for the latent endogenous variables; the Γ matrix is an $(m \times n)$ coefficient matrix for the latent exogenous variables.

The basic equations of the measurement model are the following:

$$x = \Lambda_x \xi + \delta \quad (2)$$

for the exogenous variables,

$$y = \Lambda_y \eta + \varepsilon \quad (3)$$

for the endogenous variables,

in which x and δ (delta) are column q -vectors related to the observed exogenous variables and errors, respectively; Λ_x (lambda) is a $(q \times n)$ structural coefficient matrix for the effects of the latent exogenous variables on the observed variables; y and ε (epsilon) are column p -vectors related to the observed endogenous variables and errors, respectively; Λ_y is a $(p \times m)$ structural coefficient matrix for the effects of the latent endogenous variables on the observed ones. The structural equation system is generally estimated by using the Maximum Likelihood method (ML). In other cases, the structural equation model parameters can be estimated by using other estimation methods, such as Unweighted Least Squares (ULS), Weighted Least Squares (WLS), Generalized Least Squares (GLS), and so on. These estimation methods are described in Bollen and Washington (Bollen, 1989; Washington et al., 2003), in which useful information about goodness-of-fit measures and their statistical interpretation are also provided. For a more detailed discussion on structural equation models one should refer to Joreskog, Bollen, Bagozzi and Golob (Joreskog, 1973; Bollen, 1989; Bagozzi, 1994; Golob, 2003).

4.2. Model results

In this work SEM methodology was applied for modeling the phenomenon relating to the perception of service quality by considering unobserved latent constructs representing the main service quality characteristics, and indicators representing all the observed service quality factors. In the proposed model seven ξ latent exogenous variables named as *Safety*, *Cleanliness*, *Comfort*, *Service*, *Additional Services*, *Information* and *Personnel* were introduced, together with a η latent endogenous variable, named as *Service Quality*; the latent variables are linked to 33 observed indicators or observed variables, as represented in table 3. The regression weights were obtained by solving a system of 36 equations (33 equations relating to the x exogenous variables, 2 equations to the y endogenous variables, 1 equation relating to the η latent endogenous variable). The structural equation system was estimated by using the ML method on the basis of 16,623 observations, and specifically 8,782 regarding regional services, 6,718 regarding suburban services, and 1,123 regarding express services. The model was calibrated by using the AMOS 4.0 package from SmallWaters Corporation (Arbuckle and Wothke, 1995).

The model results are reported in table 3. In the first and second column the model variables are shown; the third column shows the values of the regression weights of the coefficients (R.W.); in the fourth and fifth column the value of the standard error (S.E.) of each coefficient and the probability level (P) that the estimated coefficient is significantly different from zero are reported; finally, in the last column the values of the standardized regression weights are shown (st. R.W.). Fit indices points to a reasonably good quality of the overall model; in fact GFI (Goodness of fit index) is .648, NFI (Normed fit index) is .770, TLI (Tucker-Lewis index) is .754, CFI (Comparative fit index) is .717; besides, RMR (Root mean residual) is lower than 1.8 and RMEA (Root mean square error of approximation) is .108.

Table 3. Model results

		R.W.	S.E.	P	st. R.W.
<i>Latent endogenous variable</i>					
Service Quality (η_1)	\Leftrightarrow Safety (ξ_1)	0.049	0.007	0.000	0.095
Service Quality (η_1)	\Leftrightarrow Cleanliness (ξ_2)	0.186	0.005	0.000	0.508
Service Quality (η_1)	\Leftrightarrow Comfort (ξ_3)	0.166	0.007	0.000	0.343
Service Quality (η_1)	\Leftrightarrow Service (ξ_4)	0.260	0.007	0.000	0.507
Service Quality (η_1)	\Leftrightarrow Additional Services (ξ_5)	0.001	0.009	0.940	0.001
Service Quality (η_1)	\Leftrightarrow Information (ξ_6)	0.180	0.007	0.000	0.337
Service Quality (η_1)	\Leftrightarrow Personnel (ξ_7)	0.136	0.007	0.000	0.268
<i>Observed exogenous variable</i>					
F1 (x_1) Travel Safety	\Leftrightarrow Safety (ξ_1)	1.000	-	-	0.733
F2 (x_2) Personal Security on Board	\Leftrightarrow Safety (ξ_1)	1.351	0.012	0.000	0.965
F3 (x_3) Personal Security at Station	\Leftrightarrow Safety (ξ_1)	1.214	0.011	0.000	0.856
F4 (x_4) Cleanliness of Vehicles	\Leftrightarrow Cleanliness (ξ_2)	1.000	-	-	0.940
F5 (x_5) Cleanliness of Seats	\Leftrightarrow Cleanliness (ξ_2)	1.019	0.004	0.000	0.951
F6 (x_6) Maintenance of Seats	\Leftrightarrow Cleanliness (ξ_2)	0.969	0.005	0.000	0.911
F7 (x_7) Cleanliness of Toilet Facilities	\Leftrightarrow Cleanliness (ξ_2)	0.843	0.005	0.000	0.819
F8 (x_8) Cleanliness of Stations	\Leftrightarrow Cleanliness (ξ_2)	0.736	0.006	0.000	0.736
F9 (x_9) Maintenance of Stations	\Leftrightarrow Cleanliness (ξ_2)	0.690	0.006	0.000	0.695
F10 (x_{10}) Crowding on Board	\Leftrightarrow Comfort (ξ_3)	1.000	-	-	0.713
F11 (x_{11}) Air-conditioning on Board	\Leftrightarrow Comfort (ξ_3)	1.269	0.013	0.000	0.870
F12 (x_{12}) Comfort on Board	\Leftrightarrow Comfort (ξ_3)	1.141	0.012	0.000	0.848
F13 (x_{13}) Fare/Service Ratio	\Leftrightarrow Service (ξ_4)	1.000	-	-	0.680
F14 (x_{14}) Frequency of Runs	\Leftrightarrow Service (ξ_4)	1.092	0.012	0.000	0.773
F15 (x_{15}) Punctuality of Runs	\Leftrightarrow Service (ξ_4)	1.241	0.013	0.000	0.824
F16 (x_{16}) Regularity of Runs	\Leftrightarrow Service (ξ_4)	1.170	0.012	0.000	0.838
F17 (x_{17}) Integration with PT	\Leftrightarrow Service (ξ_4)	0.974	0.011	0.000	0.750
F18 (x_{18}) Localization of Stations	\Leftrightarrow Service (ξ_4)	0.889	0.011	0.000	0.699
F19 (x_{19}) Parking	\Leftrightarrow Additional Services (ξ_5)	0.888	0.013	0.000	0.584
F20 (x_{20}) Bicycle Transport on Board	\Leftrightarrow Additional Services (ξ_5)	0.845	0.011	0.000	0.701
F21 (x_{21}) Facilities for Disabled	\Leftrightarrow Additional Services (ξ_5)	1.084	0.013	0.000	0.750
F22 (x_{22}) Substitute Services	\Leftrightarrow Additional Services (ξ_5)	1.000	-	-	0.771
F23 (x_{23}) Information at Stations	\Leftrightarrow Information (ξ_6)	1.137	0.010	0.000	0.815
F24 (x_{24}) Information on Board	\Leftrightarrow Information (ξ_6)	1.250	0.010	0.000	0.865
F25 (x_{25}) Info Timeliness at Stations	\Leftrightarrow Information (ξ_6)	1.256	0.010	0.000	0.878
F26 (x_{26}) Info Timeliness on Board	\Leftrightarrow Information (ξ_6)	1.267	0.010	0.000	0.880
F27 (x_{27}) Complaints	\Leftrightarrow Information (ξ_6)	1.074	0.010	0.000	0.772
F28 (x_{28}) Communication to Office	\Leftrightarrow Information (ξ_6)	1.034	0.010	0.000	0.771
F29 (x_{29}) Info Connections with PT	\Leftrightarrow Information (ξ_6)	1.000	-	-	0.759
F30 (x_{30}) Kindness on Board	\Leftrightarrow Personnel (ξ_7)	1.168	0.010	0.000	0.920
F31 (x_{31}) Competence on Board	\Leftrightarrow Personnel (ξ_7)	1.165	0.009	0.000	0.939
F32 (x_{32}) Ticket Inspection	\Leftrightarrow Personnel (ξ_7)	0.968	0.011	0.000	0.692
F33 (x_{33}) Kindness of Station	\Leftrightarrow Personnel (ξ_7)	1.000	-	-	0.742
<i>Observed endogenous variable</i>					
Importance (y_1)	\Leftrightarrow Service Quality (η_1)	0.069	0.015	0.000	0.042
Satisfaction (y_2)	\Leftrightarrow Service Quality (η_1)	1.000	-	-	0.525

The latent exogenous variables with the highest positive effect on *Service Quality* are *Service* and *Cleanliness*, which have a weight each representing 25% of the sum of all the weights; also *Comfort* (17%), *Information* (16%) and *Personnel* (13%) have a notable positive effect on latent endogenous variable. On the contrary, *Safety* (5%) has a not very considerable regression weight, while *Additional Services* has no effect on *Service Quality* having a regression weight not statistically significant. The relationship between the latent endogenous variable and observed variables shows that satisfaction indicator widely explains *Service Quality* (about 93% of the total weight), while importance indicator explains a marginal part of *Service Quality* latent construct (about 7%).

By observing the relationship among the latent exogenous variables and their observed indicators, some interesting results can be highlighted. *Safety* is best explained by personal security on board (38%), while *Cleanliness* is understood prevalently as degree of cleanliness of vehicles and seats (on the whole 38%). The relationship between *Comfort* and its observed indicators shows unexpected results; in fact, *Comfort* is prevalently understood as air-conditioning (36%) and degree of comfort on board (35%), but less as level of crowding on board (29%), which often is the only comfort indicator used by the researchers which analyze service quality in public transport. The latent variable representing *Service* characteristics is well explained by regularity (18%), punctuality (18%) and frequency (17%) of runs, but also by the degree of integration between the services analyzed and others local transit services (16%). *Additional Services* are moreover understood as services substitute of irregular services (27%), besides as facilities for disabled (27%). *Information* is prevalently explained by the possibility to have some information about the services both at stations and on board, as well as the timeliness in having the information (on the whole 59%). Finally, the latent variable representing *Personnel* characteristics is best explained by kindness (28%) and competence (28%) of the personnel on board.

Model results were used for calculating an indicator of the overall service quality on the basis of the weights estimated for latent exogenous variables (according to the formula 4). The values assigned to each exogenous variable were obtained by using the estimated weights for each observed indicator and the corresponding average satisfaction rate expressed by users, as explained by 5-11 formulas.

$$\eta_1 = 0.095 \times \hat{\xi}_1 + 0.508 \times \hat{\xi}_2 + 0.343 \times \hat{\xi}_3 + 0.507 \times \hat{\xi}_4 + 0.001 \times \hat{\xi}_5 + 0.337 \times \hat{\xi}_6 + 0.268 \times \hat{\xi}_7 \quad (4)$$

$$\hat{\xi}_1 = 0.733 \times \bar{x}_1 + 0.965 \times \bar{x}_2 + 0.856 \times \bar{x}_3 \quad (5)$$

$$\hat{\xi}_2 = 0.940 \times \bar{x}_4 + 0.951 \times \bar{x}_5 + 0.911 \times \bar{x}_6 + 0.819 \times \bar{x}_7 + 0.736 \times \bar{x}_8 + 0.695 \times \bar{x}_9 \quad (6)$$

$$\hat{\xi}_3 = 0.713 \times \bar{x}_{10} + 0.870 \times \bar{x}_{11} + 0.848 \times \bar{x}_{12} \quad (7)$$

$$\hat{\xi}_4 = 0.680 \times \bar{x}_{13} + 0.773 \times \bar{x}_{14} + 0.824 \times \bar{x}_{15} + 0.838 \times \bar{x}_{16} + 0.750 \times \bar{x}_{17} + 0.699 \times \bar{x}_{18} \quad (8)$$

$$\hat{\xi}_5 = 0.584 \times \bar{x}_{19} + 0.701 \times \bar{x}_{20} + 0.750 \times \bar{x}_{21} + 0.771 \times \bar{x}_{22} \quad (9)$$

$$\hat{\xi}_6 = 0.815 \times \bar{x}_{23} + 0.865 \times \bar{x}_{24} + 0.878 \times \bar{x}_{25} + 0.880 \times \bar{x}_{26} + 0.772 \times \bar{x}_{27} + 0.771 \times \bar{x}_{28} + 0.759 \times \bar{x}_{29} \quad (10)$$

$$\hat{\xi}_7 = 0.920 \times \bar{x}_{30} + 0.939 \times \bar{x}_{31} + 0.692 \times \bar{x}_{32} + 0.742 \times \bar{x}_{33} \quad (11)$$

Service Quality indicator assumes an absolute value of 55.42; by considering that the minimum value is 8.61 (when all user express satisfaction and importance rates equal to 1), and the maximum value is 124.80 (when all user express satisfaction and importance rates equal to 10), the obtained value corresponds to 4.63 on a scale from 1 to 10, indicating a not very good level of service quality.

5. Conclusions

The weight that passengers give to each of the attributes, and the measure of their satisfaction with them help in improving service quality and preparing better investment plans; this goal is ever more important nowadays because of the growing worldwide tendency for cost reduction.

In the literature, there are many studies analyzing transit service quality based on users' perceptions in terms of satisfaction judgments. Some of them adopt SEM methodology, but no research was about railways services in Italian context. Specifically, in this work a railway service was analyzed, and in addition, a detailed and relevant number of service characteristics was investigated.

The obtained estimates can be used for improvement program for other railways services of similar kind. However, given that the impact of each service attribute could largely vary from one transit service to another, from one country to another, or even from one region to another, we can retain that the proposed framework can be generalized for analyzing any kind of service. This will provide a cost effective solution to achieve higher passenger satisfaction and a tool for a better planning fund allocation.

References

- Abreu e Silva, J., & Goulias, K. G. (2009). A Structural Equations Model of Land Use Pat-terns, Location Choice, and Travel Behavior in Seattle and Comparison with Lisbon. In Proceedings of the 88th Annual Transportation Research Board Meeting, January 11-15, 2009, Washington D.C.
- Andreassen, T. W. 1995. (Dis)satisfaction with public services: the case of public transportation. *Journal of Services Marketing*, 9, 30-41.
- Arbuckle, J. L., & Wothke W. (1995). AMOS 4.0 User's Guide. Chicago: SmallWaters Corporation.
- Bagozzi, R.P. (1994). Structural Equations Models in Marketing: Basic Principles. In R.P. Bagozzi (Ed.), *Principles of Marketing Research* (pp. 317-385). Cambridge: Blackwell.
- Bamberg, S., & Schmidt P. (1998). Changing Travel-Mode Choice as Rational Choice: Results from a Longitudinal Intervention Study. *Rationality and Society*, 10(2), 223-252.
- Bollen, K.A. (1989). *Structural Equations with Latent Variables*. New York: Wiley.
- Changa, Y. H. & Chen, F. Y. (2007). Relational benefits, switching barriers and loyalty: A study of airline customers in Taiwan. *Journal of Air Transport Management*, 13, 104-109.
- Chenga, J. H., Chen, F. Y. & Chang, Y. H. (2008). Airline relationship quality: An examination of Taiwanese passengers. *Tourism Management*, 29, 487-499.
- Ching-Chiao, Y., Peter, B., Marlow, & Chin-Shan, L. (2009). Assessing resources, logistics service capabilities, innovation capabilities and the performance of container shipping services in Taiwan. *International Journal of Production Economics*, 122, 4-20.
- Chin-Shan, L. (2007). Evaluating key resources and capabilities for liner shipping services. *Transport Reviews*, 27(3), 285-310.
- Fillone, A. M., Montalbo, C. M., & Tiglaio, N. C. (2005). Assessing Urban Travel: a Structural Equations Modeling (SEM) Approach. In Proceedings of the Eastern Asia Society for Transportation Studies, 5, 1050-1064.
- Golob, T.F. (2003). Structural Equation Modeling. In K.G. Goulias (Ed.) *Transportation systems planning* (11, pp. 1-23). Boca Raton: CRC Press.
- Irfan Syed Muhammad, Mui Hung Kee Daisy, & Shahbaz Saman (2011). Service Quality in Rail Transport of Pakistan: A Passenger Perspective. In Proceedings of 3rd SAICON: International Conference on Management, Business Ethics and Economics (ICMBEE), December 28-29, 2011, Lahore, Pakistan.
- Joreskog, K. G. (1973). Analysis of covariance structures. In P. R. Krishnaiah (Ed.), *Multivariate Analysis-III* ed. (pp. 263-285). New York: Academic Press.
- Joreskog, K. G., & Sorbom D. (1988). PRELIS: A Program for Multivariate Data Screening and Data Summarization. A Preprocessor for LISREL. Chicago: SSI, Inc.
- Joreskog, K. G., & Sorbom D. (1989). LISREL 7: A Guide to the Program and Applications. Chicago: SPSS, Inc.
- Joreskog, K. G., & Sorbom D. (1995). LISREL 8: Scientific Software International. Chicago: Inc.
- Karlaftis, M. G., Golias, J., & Papadimitriou E. (2001). Transit Quality as an Integrated Traffic Management Strategy: Measuring Perceived Service. *Journal of Public Transportation*, 4(1).
- Kolanovic, I. (2008). Defining the port service quality using factor analysis, *Pomorstvo*. 22(2), 83-297.
- Lai, W. T., & Chen, C. F. (2010). Behavioural intentions of public transit passengers -The roles of service quality, perceived value, satisfaction and involvement. *Transport Policy*, 18, 318-325.
- Ngatia G. J., Okamura T., & Nakamura F. (2010) The Structure of Users' Satisfaction on Urban Public Transport Service in Developing Country: the Case of Nairobi. *The Journal of the Eastern Asia Society for Transport Studies*, 8.
- Nocera S. (2011). The key role of quality assessment in public transport policy. *Traffic Engineering and Control*, 52(9), 394-398.
- Pantouvakis, A. (2010). The relative importance of service features in explaining customer satisfaction-A comparison of measurement models. *Managing Service Quality*, 20(4), 366-387.
- Rahaman, R. K., & Rahaman, Md. A. (2009). Service quality attributes affecting the satisfaction of passengers of a selective route in southwestern Bangladesh. *Theoretical and Empirical Researches in Urban Management*, 3(12), 115-125.
- Sezhian, M. V., Muralidharan, C., Nambirajan, T., & Deshmukh, S. G. (2011). Ranking of a public sector passenger bus transport company using principal component analysis: a case study.
- Stuart, K. R., Mednick, M., & Bockman, J. (2000). Structural equation model of customer satisfaction for the New York City subway system.

- Transportation Research Record, 1735, 133-137.
- Tam, Mei Ling, Mei Lang Tam, & Lam W. H. K.. (2005). Analysis of Airport Access Mode Choice: a Case Study in Hong Kong. *Journal of the Eastern Asia Society for Transportation Studies*, 6, 708-723.
- Tschopp, M., & Axhausen, K. W. (2007). Transport infrastructure and spatial development in Switzerland between 1950 and 2000. In *Proceedings of 86th Annual Meeting of the Transportation Research Board*, January 2007, Washington, D.C.
- Van Acker, V., Witlox, F., & Van Wee, B. (2007). The Effects of the Land Use System on Travel Behavior: A Structural Equation Modeling Approach. *Transportation Planning and Technology*, 30(4), 331-353.
- Washington, S. P., Karlaftis M. G., & Mannering F. L. (2003). *Statistical and Econometric Methods for Transportation Data Analysis*. Florida: Chapman & Hall/CRC Press.
- Wiley, D. E. (1973). The identification problem for structural equation models with unmeasured variables. In A.S. Goldberger, & O.D. Duncan (Eds.), *Structural Equation Models in the Social Science* (pp.69-83). New York: Seminar Press.
- Yu, K.K. & Lee, H. R. (2011). Customer satisfaction using low cost carriers. *Tourism Management*, 32, 235-243.